

**OAK RIDGE NATIONAL LABORATORY
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POST OFFICE BOX 2008, OAK RIDGE, TENNESSEE 37831-6170**

ORNL

FOREIGN TRIP REPORT

TA 430696

DATE: December 14, 2018

SUBJECT: Report of Foreign Travel to Geel, Belgium – Klaus H. Guber, Reactor and Nuclear Systems Division

TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Klaus H. Guber

**MEETING:
TITLE** N/A

**MEETING:
LOCATION** JRC-Geel, Geel, Belgium

**MEETING:
DATES** 11/13/2018 – 12/12/2018

**ATTENDEES:
ON BEHALF
OF NCSP** Klaus H. Guber

**MEETING:
BENEFIT TO
NCSP** Dr. Guber is a nuclear data specialist who has experience in nuclear data measurements, and he traveled to Geel, Belgium to perform neutron cross-section measurements using the Geel Electron Linear Accelerator (GELINA) at JRC-Geel. The measurements have been performed in accordance with the Nuclear Criticality Safety Program (NCSP) Five Year Plan, and the measurements provide needed nuclear data for the NCSP.

PURPOSE: The main purpose of the travel is to perform nuclear cross-section measurements at the Joint Research Center of the European Union (JRC-Geel) in Geel, Belgium. The primary objective during this trip was to initiate neutron induced cross-section measurements on for a ^{142}Ce sample at JRC-Geel. Furthermore, additional work includes data reduction and sorting tasks for previous measurement campaigns for the La sample transmission and capture data at JRC-Geel. All of these work tasks have been performed for the NCSP, and the nuclear data measurement work is performed in collaboration with JRC-Geel of the European Community.

**SITES:
VISITED** The Joint Research Institute of the European Community, Geel, Belgium

ABSTRACT: The traveler visited JRC-Geel in Geel, Belgium. At JRC-Geel, the objective of the visit is to initiate neutron transmission and capture cross-section measurements for a ^{142}Ce using sample at the GELINA facility. During the visit, Guber performed data reduction tasks for La transmission and capture data obtained through measurements with a thin and thick sample.

**Access to the information in this report is limited to those indicated
on the distribution list and to U.S. Government Agencies and their Contractors.**

REPORT OF FOREIGN TRAVEL

**Klaus Guber
Geel, Belgium**

November 13 – December 12, 2018

PURPOSE OF TRAVEL

The main purpose of the travel is to perform nuclear cross-section measurements at JRC-Geel in Geel, Belgium. The first objective of this trip was to initiate transmission and neutron capture cross-section measurements on a Ce-142 sample at JRC-Geel. Secondly, data sorting and reduction for the newly La sample data was to be continued (see previous report). These work tasks have been performed for the NCSP, and the nuclear data measurement work is performed in collaboration with JRC-Geel of the European Community.

Report

Klaus Guber traveled to JRC-Geel to perform nuclear data measurement and analysis work for the NCSP. At JRC-Geel, the GELINA (Geel Electron Linear Accelerator) neutron facility can be used to perform neutron-induced cross-section measurements in the neutron energy range from thermal up to ~20 MeV that includes the resonance region for many isotopes/nuclides of interest to the NCSP. GELINA is similar in capability to the Oak Ridge Electron Linear Accelerator (ORELA) in the U.S.; however, ORELA is no longer available for performing neutron cross-section measurements. GELINA is a neutron source driven by a pulsed electron beam, which produces neutrons via Bremsstrahlung from a uranium target. Due to a special compression system, the accelerated electron pulse of GELINA can be compressed to one nsec pulse width at full power. In combination with a long flight path, the GELINA facility provides excellent time-of-flight (TOF) resolution, which determines the neutron energy. Therefore, individual resonances of the cross section can be resolved at much higher neutron energies, and this neutron energy-resolution capability is essential for determining the detailed neutron cross-section structure for nuclides of importance to criticality safety applications.

In the course of this trip, neutron cross-section measurements for Ce-142 were to be initiated. However, even though the sample was ordered well in advance, the sample arrived at JRC-Geel one week before the end of this trip. ORNL isotopes division had trouble in producing a pressed disk of CeO₂ and weld the Al containers. In fact, the quality of the empty container needed for correction of the data, was in such a bad shape that a new one was ordered. Hence, the measurements could not be started since JRC-Geel was then running under beam condition not favorable for the planned experiments. For this reason, the Ce-142 experiments will start in 2019 when the new empty container has arrived.

Beside the experiments, another focus on this trip was to finalize the data sorting tasks at JRC-Geel for the previous neutron transmission experiment measurements using La samples and sort the neutron capture data for the La samples into TOF spectra. For this task, the GELINA specific software packages AGL and AGS were used. In the first step, all runs were checked for consistency using the recorded scalars. In a second step the accepted list mode data runs were sorted into TOF spectra. For the transmission experiments this data conversion was completed for the sample in and sample out as well as various runs with black resonance filters. With AGS, the data can be converted to cross-section data or transmission data, respectively. The GELINA data-reduction software enables the experimentalist to process all experimental

uncertainties in a consistent way to produce a covariance matrix describing all experimental effects, and the experimental covariance data are essential for supporting the cross-section covariance evaluation effort.

Based on preliminary analysis of the La data, the measured cross-section data are useful to support subsequent resonance evaluation work at ORNL as planned in the NCSP Five Year Plan. GELINA's high neutron flux in combination with a short pulse width and long flight path might enable ORNL to extend the resolved resonance region for La beyond the existing resonance evaluation limit. In the high-energy neutron region, the dominating factor determining neutron energy resolution is the neutron pulse width.

The traveler had discussion with Prof. C. Wagemans about his old $^{35}\text{Cl}(n,p)$ experiments and how to overcome ^{35}Cl sample related problems. $^{35}\text{Cl}(n,p)$ is in the NCSP Five Year Plan.

Overall, Guber's foreign travel to JRC-Geel was essential to enable ORNL to complete the planned NCSP measurement and evaluation tasks as defined in the NCSP Five Year Plan.

Persons Contacted at JRC-Geel

Peter Schillebeeckx, Host
Arjan Plompen, Section Head NP Unit
Peter Siegler
Stefan Kopecky
Jan Heyse

Itinerary and Schedule

11/13/18 – 11/14/18	Travel from Knoxville to Geel, Belgium
11/14/18 – 11/16/18	JRC-Geel -GELINA, Geel, Belgium. Preparing capture data from previous La runs for sorting into TOF spectra. Finalized La transmission data.
11/17/18 – 11/18/18	Weekend
11/19/18 – 11/23/18	JRC-Geel -GELINA, Geel, Belgium. List mode data sorting for $\text{La}(n,\gamma)$ experiments using thin and thick sample data. Various runs with background filters, normalization runs, empty Al can and scattering sample were sorted.
11/24/18 – 11/25/18	Weekend
11/26/18 – 11/30/18	JRC-Geel -GELINA, Geel, Belgium. List mode data sorting for $\text{La}(n,\gamma)$ experiments using thin and thick sample data. Various runs with background filters, normalization runs, empty Al can and scattering sample were sorted.
12/01/18 – 12/02/18	Weekend
12/03/18 – 12/07/18	JRC-Geel -GELINA, Geel, Belgium. List mode data sorting for $\text{La}(n,\gamma)$ experiments using thin and thick sample data. Various runs with background filters, normalization runs, empty Al can and scattering sample were sorted. Discussion with Prof. C. Wagemans about his old $^{35}\text{Cl}(n,p)$ experiments and how to overcome ^{35}Cl sample related problems. Ce-142 sample arrived at JRC.
12/08/18 – 12/09/18	Weekend
12/10/18 – 12/11/18	JRC-Geel -GELINA, Geel, Belgium. List mode data sorting for $\text{La}(n,\gamma)$ experiments using thin and thick sample data. Various runs with background filters, normalization runs, empty Al can and scattering sample were sorted. Storing of sorted data to removable media for transport to ORNL.
12/12/18	Travel from Geel, Belgium to Knoxville, USA

DISTRIBUTION

1. Doug G. Bowen (bowendg@ornl.gov)
2. Angela Chambers (angela.chambers@nnsa.doe.gov)
3. Lori Scott (Lorisc0tt@aol.com)

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ORNL

FOREIGN TRIP REPORT

TA 435569

DATE: April 24, 2019

SUBJECT: Report of Foreign Travel to Geel, Belgium – Klaus H. Guber, Reactor and Nuclear Systems Division

TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Klaus H. Guber

**MEETING:
TITLE** N/A

**MEETING:
LOCATION** JRC-Geel, Geel, Belgium

**MEETING:
DATES** 03/20/2019 – 04/12/2019

**ATTENDEES:
ON BEHALF
OF NCSP** Klaus H. Guber

**MEETING:
BENEFIT TO
NCSP** Dr. Guber is a nuclear data specialist who has experience in nuclear data measurements, and he traveled to Geel, Belgium to perform neutron cross-section measurements using the Geel Electron Linear Accelerator (GELINA) at JRC-Geel. The measurements have been performed in accordance with the Nuclear Criticality Safety Program (NCSP) Five Year Plan, and the measurements provide needed nuclear data for the NCSP.

PURPOSE: The main purpose of the travel is to perform nuclear cross-section measurements at the Joint Research Center of the European Union (JRC-Geel) in Geel, Belgium. The primary objective during this trip was to continue neutron induced cross-section measurements on for a ^{142}Ce sample at JRC-Geel. Furthermore, additional work includes data reduction and sorting tasks for measurement campaigns for the ^{142}Ce sample transmission data at JRC-Geel. All of these work tasks have been performed for the NCSP, and the nuclear data measurement work is performed in collaboration with JRC-Geel of the European Community.

**SITES:
VISITED** The Joint Research Institute of the European Community, Geel, Belgium

ABSTRACT: The traveler visited JRC-Geel in Geel, Belgium. At JRC-Geel, the objective of the visit is to continue neutron transmission and capture cross-section measurements for a ^{142}Ce using sample at the GELINA facility. During the visit, Guber started data reduction tasks for ^{142}Ce transmission and initiated capture experiments.

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REPORT OF FOREIGN TRAVEL

**Klaus Guber
Geel, Belgium**

November 13 – December 12, 2018

PURPOSE OF TRAVEL

The main purpose of the travel is to perform nuclear cross-section measurements at JRC-Geel in Geel, Belgium. The first objective of this trip was to initiate neutron capture cross-section measurements on a Ce-142 sample at JRC-Geel. Secondly, data sorting for the ^{142}Ce sample transmission data was started. These work tasks have been performed for the NCSP, and the nuclear data measurement work is performed in collaboration with JRC-Geel of the European Community.

Report

Klaus Guber traveled to JRC-Geel to perform nuclear data measurement and analysis work for the NCSP. At JRC-Geel, the GELINA (Geel Electron Linear Accelerator) neutron facility can be used to perform neutron-induced cross-section measurements in the neutron energy range from thermal up to ~ 20 MeV that includes the resonance region for many isotopes/nuclides of interest to the NCSP. GELINA is similar in capability to the Oak Ridge Electron Linear Accelerator (ORELA) in the U.S.; however, ORELA is no longer available for performing neutron cross-section measurements. GELINA is a neutron source driven by a pulsed electron beam, which produces neutrons via Bremsstrahlung from a uranium target. Due to a special compression system, the accelerated electron pulse of GELINA can be compressed to one nsec pulse width at full power. In combination with a long flight path, the GELINA facility provides excellent time-of-flight (TOF) resolution, which determines the neutron energy. Therefore, individual resonances of the cross section can be resolved at much higher neutron energies, and this neutron energy-resolution capability is essential for determining the detailed neutron cross-section structure for nuclides of importance to criticality safety applications.

In the course of this trip, neutron cross-section measurements for Ce-142 were to be continued. The last trip planned and then postponed transmission experiment for Ce-142 due to not acceptable sample containers were started in beginning of 2019. The experiments were finalized during this trip and the capture experiments for Ce-142 were initiated. These experiments include runs for the empty sample container, scattering sample and normalizations runs.

Since the transmission experimental data for the Ce-142 sample were already available, the sorting procedure of the list mode data was started. For this task, the GELINA specific software packages AGL and AGS were used. In the first step, all runs were checked for consistency using the recorded scalers. In a second step the accepted list mode data runs were sorted into TOF spectra. For the transmission experiments this data conversion was completed for the sample in and sample out as well as various runs with black resonance filters. With AGS, the data can be converted to cross-section data or transmission data, respectively. The GELINA data-reduction software enables the experimentalist to process all experimental uncertainties in a consistent way to produce a covariance matrix describing all experimental effects, and the experimental covariance data are essential for supporting the cross-section covariance evaluation effort.

Additionally, the neutron capture data for a thick V sample were reduced to cross section. Observed abnormalities in the TOF spectra were discussed with JRC personnel. It was concluded that the observed effect is due to sample scattered neutron and the experimental set up geometry. The scattered neutrons get backscattered into the detectors and captured in the Al housing of the detectors.

Based on preliminary results the Ce-142 transmission data will be useful to support subsequent resonance evaluation work at ORNL as planned in the NCSP Five Year Plan. GELINA's high neutron flux in combination with a short pulse width and long flight path might enable ORNL to extend the resolved resonance region for La beyond the existing resonance evaluation limit. In the high-energy neutron region, the dominating factor determining neutron energy resolution is the neutron pulse width.

Presentation from Giles Noguerre from CEA Cadarache, France about the CEA burn up credit program using the MINERVA experimental data.

Overall, Guber's foreign travel to JRC-Geel was essential to enable ORNL to complete the planned NCSP measurement and evaluation tasks as defined in the NCSP Five Year Plan.

Persons Contacted at JRC-Geel

Peter Schillebeeckx, Host
Arjan Plompen, Section Head NP Unit
Peter Siegler
Stefan Kopecky
Jan Heyse

Itinerary and Schedule

03/20/19 – 03/21/19	Travel from Knoxville to Geel, Belgium
03/21/19 – 03/22/19	JRC-Geel -GELINA, Geel, Belgium. Preparing neutron capture experiments. Continue Ce-142 transmission run.
03/23/19 – 03/24/19	Weekend
03/25/19 – 03/29/19	JRC-Geel -GELINA, Geel, Belgium. Preparing neutron capture experiments. Continue Ce-142 transmission runs until middle of week. Start Ce-142 capture experiments.
03/30/19 – 03/31/19	Weekend
04/01/19 – 04/05/19	JRC-Geel -GELINA, Geel, Belgium. Continue Ce-142 capture experiments. Start sorting Ce-142 transmission data into TOF spectra. Start thick V sample capture data reduction. Examination of the experimental effect for the V capture experiments.
04/06/19 – 04/07/19	Weekend
04/08/19 – 04/11/19	JRC-Geel -GELINA, Geel, Belgium. Continue Ce-142 capture experiments. Continue sorting Ce-142 transmission data into TOF spectra. Thick V sample capture data reduction.
04/12/19	Travel from Geel, Belgium to Knoxville, USA

DISTRIBUTION

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ORNL

FOREIGN TRIP REPORT

TA 440192

DATE: July 24, 2019

SUBJECT: Report of Foreign Travel to Geel, Belgium – Klaus H. Guber, Reactor and Nuclear Systems Division

TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Klaus H. Guber

**MEETING:
TITLE** N/A

**MEETING:
LOCATION** JRC-Geel, Geel, Belgium

**MEETING:
DATES** 06/18/2019 – 07/14/2019

**ATTENDEES:
ON BEHALF
OF NCSP** Klaus H. Guber

**MEETING:
BENEFIT TO
NCSP** Dr. Guber is a nuclear data specialist who has experience in nuclear data measurements, and he traveled to Geel, Belgium to perform neutron cross-section measurements using the Geel Electron Linear Accelerator (GELINA) at JRC-Geel. The measurements have been performed in accordance with the Nuclear Criticality Safety Program (NCSP) Five Year Plan, and the measurements provide needed nuclear data for the NCSP.

PURPOSE: The main purpose of the travel is to perform nuclear cross-section measurements at the Joint Research Center of the European Union (JRC-Geel) in Geel, Belgium. The primary objective during this trip was to continue neutron induced cross-section measurements on for a ^{142}Ce sample at JRC-Geel. Furthermore, additional work includes data reduction and sorting tasks for measurement campaigns for the ^{142}Ce sample transmission and capture data at JRC-Geel. All of these work tasks have been performed for the NCSP, and the nuclear data measurement work is performed in collaboration with JRC-Geel of the European Community.

**SITES:
VISITED** The Joint Research Institute of the European Community, Geel, Belgium

ABSTRACT: The traveler visited JRC-Geel in Geel, Belgium. At JRC-Geel, the objective of the visit is to continue neutron capture cross-section measurements for a ^{142}Ce using sample at the GELINA facility. During the visit, Guber finalized data sorting tasks for ^{142}Ce transmission and capture experiments.

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REPORT OF FOREIGN TRAVEL

**Klaus Guber
Geel, Belgium**

November 13 – December 12, 2018

PURPOSE OF TRAVEL

The main purpose of the travel is to perform nuclear cross-section measurements at JRC-Geel in Geel, Belgium. The first objective of this trip was to continue neutron capture cross-section measurements on a Ce-142 sample at JRC-Geel. Secondly, data sorting for the ^{142}Ce sample transmission data was finalized and capture data sorting was started. These work tasks have been performed for the NCSP, and the nuclear data measurement work is performed in collaboration with JRC-Geel of the European Community.

Report

Klaus Guber traveled to JRC-Geel to perform nuclear data measurement and analysis work for the NCSP. At JRC-Geel, the GELINA (Geel Electron Linear Accelerator) neutron facility can be used to perform neutron-induced cross-section measurements in the neutron energy range from thermal up to ~20 MeV that includes the resonance region for many isotopes/nuclides of interest to the NCSP. GELINA is similar in capability to the Oak Ridge Electron Linear Accelerator (ORELA) in the U.S.; however, ORELA is no longer available for performing neutron cross-section measurements. GELINA is a neutron source driven by a pulsed electron beam, which produces neutrons via Bremsstrahlung from a uranium target. Due to a special compression system, the accelerated electron pulse of GELINA can be compressed to one nsec pulse width at full power. In combination with a long flight path, the GELINA facility provides excellent time-of-flight (TOF) resolution, which determines the neutron energy. Therefore, individual resonances of the cross section can be resolved at much higher neutron energies, and this neutron energy-resolution capability is essential for determining the detailed neutron cross-section structure for nuclides of importance to criticality safety applications.

In the course of this trip, neutron cross-section measurements activities for Ce-142 were to be continued. The capture experiments for Ce-142 were finalized during this trip. These experiments include runs for the empty sample container, scattering sample and normalizations runs.

The sorting procedure of the list mode data for Ce-142 capture was started. For this task, the GELINA specific software packages AGL and AGS were used. In the first step, all runs were checked for consistency using the recorded scalars. In a second step the accepted list mode data runs were sorted into TOF spectra. For the transmission experiments this data conversion was completed for the sample in and sample out as well as various runs with black resonance filters. With AGS, the data can be converted to cross-section data or transmission data, respectively. The GELINA data-reduction software enables the experimentalist to process all experimental uncertainties in a consistent way to produce a covariance matrix describing all experimental effects, and the experimental covariance data are essential for supporting the cross-section covariance evaluation effort.

Furthermore, it was determined that additional transmission experiments should be performed to obtain better statistic, since the current experiments were performed with a neutron beam collimation which cuts

down the beam size in half. A larger beam can be obtained by changing the collimation; these experiments are planned for the first quarter of FY20.

In addition, the neutron capture data for a thick Cr-53 sample was revisited. Observed abnormalities in the cross section were discussed with JRC personnel. It was concluded that the observed effect is due to sample scattered neutron and self-shielding effects in the rather thick sample. Therefore the data for Cr-53 capture cannot be used below 10 keV and new experiments with a strongly diluted sample are needed.

Based on preliminary results the Ce-142 transmission and capture data will be useful to support subsequent resonance evaluation work at ORNL as planned in the NCSP Five Year Plan. GELINA's high neutron flux in combination with a short pulse width and long flight path might enable ORNL to extend the resolved resonance region for La beyond the existing resonance evaluation limit. In the high-energy neutron region, the dominating factor determining neutron energy resolution is the neutron pulse width.

Overall, Guber's foreign travel to JRC-Geel was essential to enable ORNL to complete the planned NCSP measurement and evaluation tasks as defined in the NCSP Five Year Plan.

Persons Contacted at JRC-Geel

Peter Schillebeeckx, Host
Arjan Plompen, Section Head NP Unit
Peter Siegler
Stefan Kopecky
Jan Heyse

Itinerary and Schedule

06/18/19 – 06/19/19	Travel from Knoxville to Geel, Belgium
06/19/19 – 06/21/19	JRC-Geel -GELINA, Geel, Belgium. Continue Ce-142 capture run. Start data sorting for transmission experiments.
06/22/19 – 06/23/19	Weekend
06/24/19 – 06/28/19	JRC-Geel -GELINA, Geel, Belgium. Continue Ce-142 capture experiments. Continue data sorting for transmission experiments. Start data sorting for capture experiments.
06/29/19 – 06/30/19	Weekend
07/01/19 – 07/05/19	JRC-Geel -GELINA, Geel, Belgium. Continue Ce-142 capture experiments. Continue sorting Ce-142 capture data into TOF spectra.
07/06/19 – 07/13/19	Personal time in Germany.
07/14/19	Travel from Brussels, Belgium to Knoxville, USA

DISTRIBUTION

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